Guide for Reading

Focus on this question as you read.

▶ *What path does blood take through the circulatory system?*

4–2 Circulation in the Body

In a way, the entire circulatory system is like a vast maze that starts at the heart. Unlike most mazes, however, this one always leads back to the place where it began. **In the circulatory system, blood moves from the heart to the lungs and back to the heart. Blood then travels to all the cells of the body and returns again to the heart.** In the next few pages, you will follow the blood on its journey through the circulatory maze. You will begin, of course, at the heart.

You may be surprised to learn that the heart is a muscle that rests only between beats. Even when you are asleep, about 5 liters of blood is pumped through your body every minute. During an average lifetime, the heart beats more than 2 billion times and pumps several hundred million liters of blood through the many thousands of kilometers of blood vessels in the body.

Not much larger than a fist, the heart is located slightly to the left of the center of your chest. If you place your fingers there and gently press down, you probably will be able to feel your heart beating. The heartbeat, or the heart's rhythm, is controlled by an area of nerve tissue within the heart. Because this

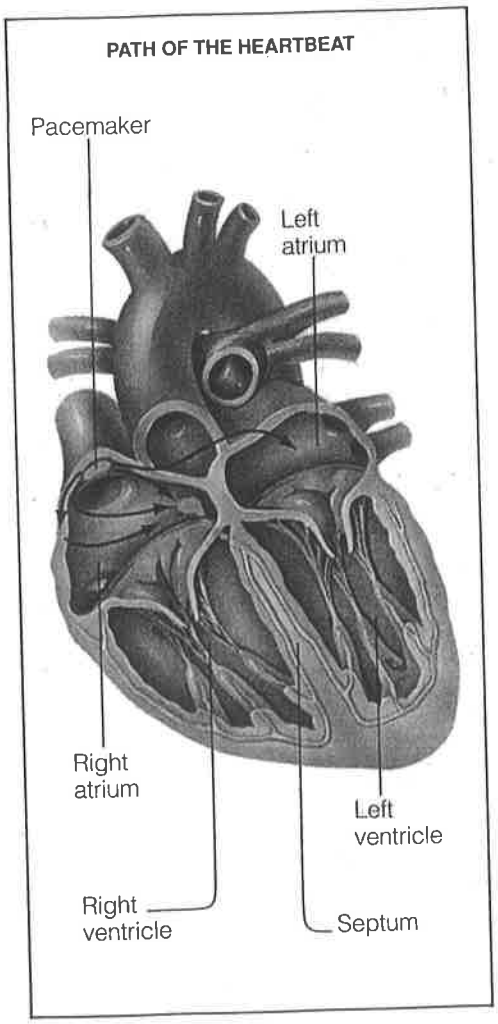


Figure 4–3 *The heartbeat is controlled by an area of nerve tissue within the heart called the pacemaker. In the illustration, you can see the path a message from the pacemaker takes as it spreads through the heart. The photograph shows a network of nerves lining a section of a ventricle.*

area regulates the heart's pace, or rate of beating, it is called the pacemaker. Located in the upper-right side of the heart, the pacemaker sends out signals to heart muscle, causing it to contract. For a variety of reasons, the body's pacemaker may fail to operate properly. If this happens, an artificial pacemaker, complete with a battery, can be inserted into the body or worn outside the body.

The Right Side of the Heart

Most people think of the heart as a single pump, but it is actually two pumps. One pump is located on the right side of the heart. The second pump is located on the left side of the heart. A thick wall of tissue called the septum separates the heart into a right side and a left side. Each side has two chambers. Your journey through the circulatory maze begins in the right upper chamber, called the right **atrium** (AY-tree-uhm; plural: atria). Figure 4–4 shows the location of the right atrium.

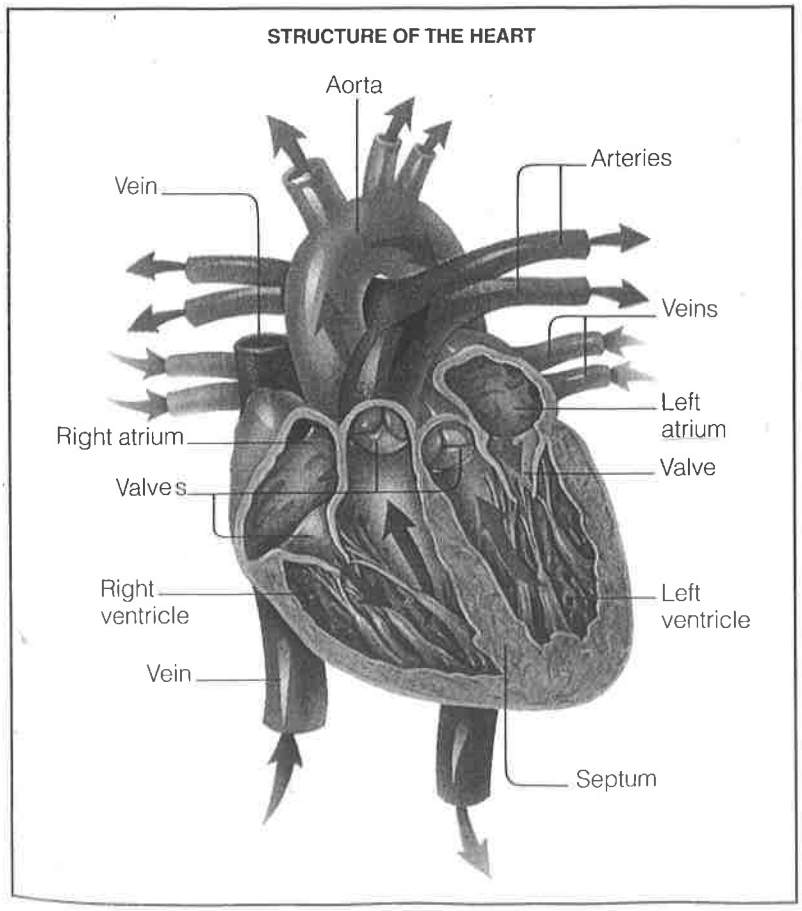


Figure 4–4 *The heart is divided into a right side and a left side by a septum, or wall. Each side of the septum contains two chambers: an upper chamber and a lower chamber. The upper chambers are called atria, and the lower chambers are called ventricles. What is the function of the atria?*

ACTIVITY DISCOVERING

Catch the Beat

How does temperature affect heartbeat rate? Design an experiment to find the answer to this question by using the following materials:

Daphnia culture
2 glass depression slides
coverslip
microscope
stopwatch
ice cube

As you plan your experiment, keep in mind that it must contain only one variable. Remember to include a control.

- What effect would warm (not hot) water have on the *Daphnia*'s heartbeat rate?

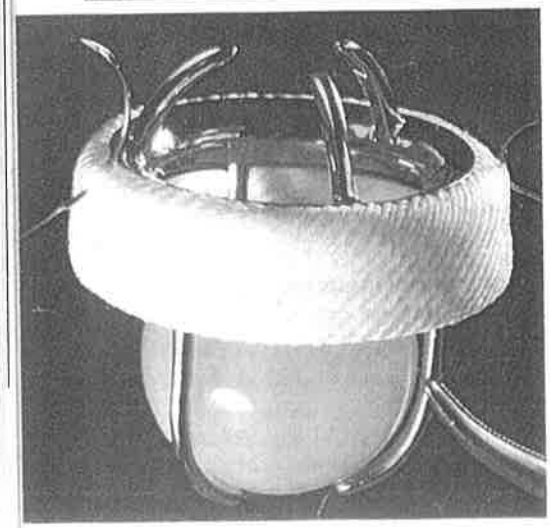
Activity Bank

You've Got to Have Heart, p. 251

Inside the right atrium, you find yourself swirling in a dark sea of blood. A great many red blood cells surround you. Red blood cells carry oxygen throughout the body. When the hemoglobin in the red blood cells join up with oxygen molecules, the blood turns bright red. Such blood is said to be oxygen-rich. The blood in which you are swimming in the right atrium, however, is dark red, not bright red at all. This can only mean that these red blood cells are not carrying much oxygen. Rather, they are carrying mostly the waste gas carbon dioxide. This blood, then, is oxygen-poor. And that makes sense. For the right atrium is a collecting chamber for blood returning from its trip through the body. Along the way, the red blood cells have dropped off most of their oxygen and picked up carbon dioxide.

Suddenly the blood begins to churn, and you feel yourself falling downward. You are about to enter the heart's right lower chamber, called the right **ventricle.** But before you do, you must pass through a small flap of tissue called a valve. The valve opens to allow blood to go from the upper chamber to the lower chamber. Then it closes immediately to prevent blood from backing up into the upper chamber.

You now find yourself in the right ventricle. Your stay here will be quite short. The ventricles, unlike the atria, are pumping chambers. Before you know it, you feel the power of a heartbeat as the ventricle contracts and blood is forced out of the heart through a large blood vessel.



To the Lungs and Back

Now your journey has really begun. Because you are surrounded by oxygen-poor blood, your first stop should be obvious. Do you know what it is? The right ventricle is pumping you toward the lungs. The trip to the lungs is a short one. In the lungs, the red blood cells drop off the waste gas carbon dioxide. As the carbon dioxide enters the lungs, it is immediately

Figure 4–5 *Heart valves control the flow of blood through the heart. A heart valve called the bicuspid valve (top) is found between the left atrium and the left ventricle. Sometimes when a natural heart valve does not work properly, it must be replaced by an artificial heart valve (bottom).*

exhaled (breathed out). At the same time, the red blood cells are busy picking up oxygen, which has been brought into the lungs as a result of inhaling (breathing in). What is the color of the blood now?

As you leave the lungs, you might be expecting to travel with the oxygen-rich blood to all parts of the body. But to your surprise, you discover this is not the case. The oxygen-rich blood you are traveling in must first return to the heart so that it can be pumped throughout the body. Your next stop is the hollow chamber known as the left atrium.

The Left Side of the Heart

The left atrium, like the right atrium, is a collecting chamber for blood returning to the heart. The left atrium, however, collects oxygen-rich blood as it returns from the lungs. Once again, the blood quickly flows downward through a valve and enters the left ventricle.

The left ventricle has a lot more work to do than the right ventricle does. The right ventricle has to pump blood only a short distance to the lungs. But the left ventricle has to pump blood to every part of the body. In fact, the left side of the heart works about six times harder than the right side. That is why you feel your heartbeat on the left side of your chest.

Arteries: Pipelines From the Heart

As the left ventricle pumps the oxygen-rich blood out of the heart, the blood passes through the largest blood vessel in the body. This blood vessel is called the aorta (ay-OR-tuh). The aorta is an **artery,** or a blood vessel that carries blood away from the heart.

Soon after leaving the heart, the aorta branches into smaller arteries. Some of these smaller arteries return immediately to the heart, supplying the heart muscle with food and oxygen. Others branch again and again, like the branches of a tree. These branching arteries form a network that connects all parts of the body.

As you pass through the aorta and enter a smaller artery, you notice that the inner wall of the artery is

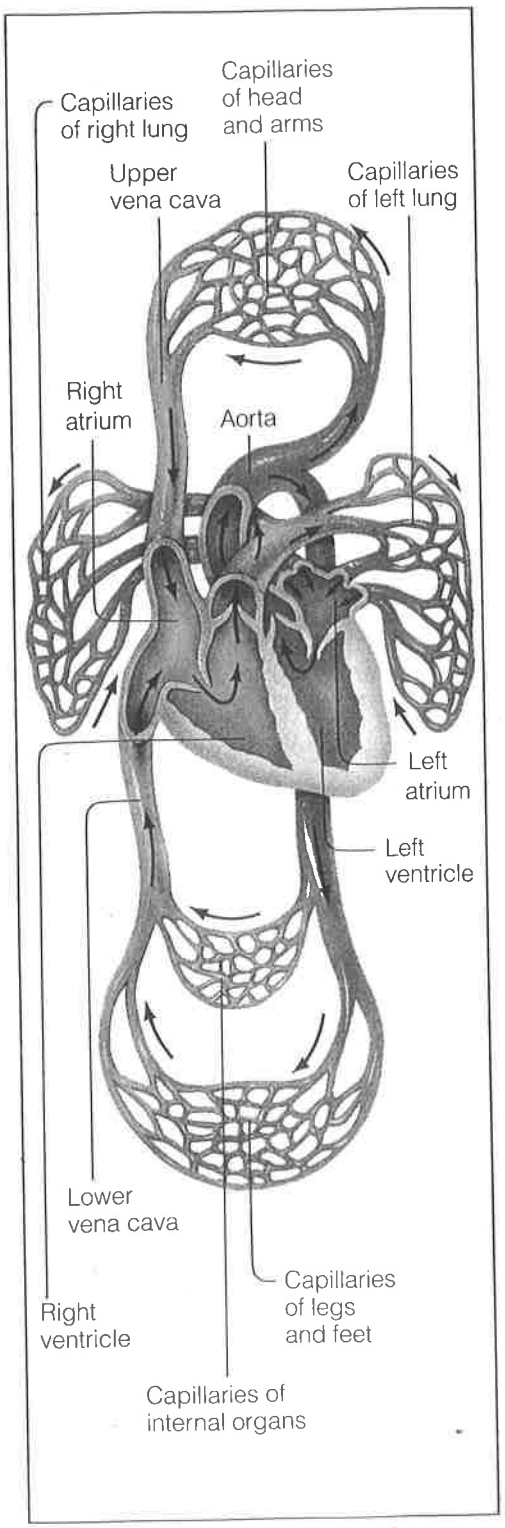


Figure 4–6 *Blood travels through the body in a continuous path. The path of oxygen-rich blood is shown in red, and the path of oxygen-poor blood is shown in blue.*

ACTIVITY DOING

Circulation

Human circulation is divided into two types of circulation: pulmonary circulation and systemic circulation.

Use reference books to find out the structures that are involved in each type of circulation. Draw a labeled diagram of the human circulatory system, using two different-colored pencils to illustrate the structures that make up each type of circulation.

Why do you think these two types of circulation are so named?

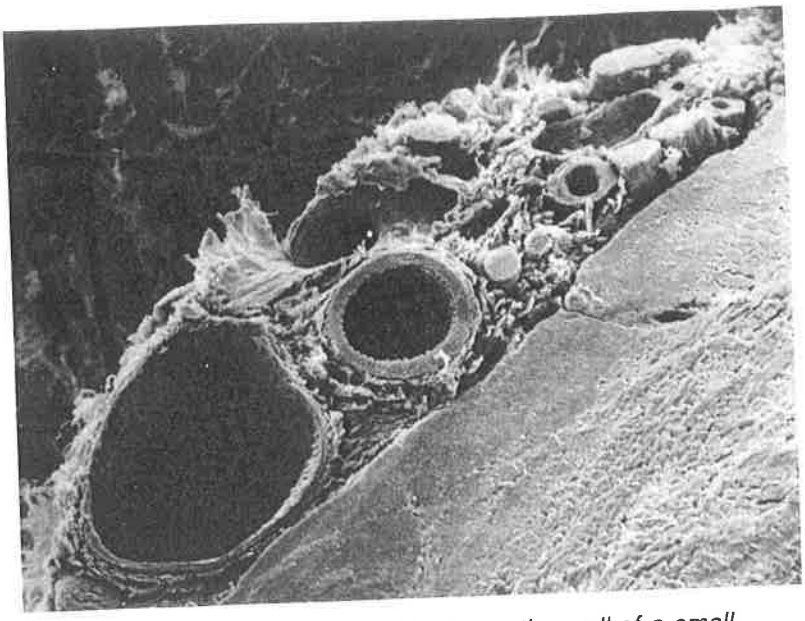


Figure 4–7 *This photograph shows that the wall of a small artery (right) is thicker than the wall of a medium-sized vein (left).*

quite smooth. The smooth inner wall allows blood to flow freely. Around the smooth inner wall is an elastic middle layer that is made mainly of smooth muscle tissue. Much of the flexibility of arteries comes from this elastic middle layer. The flow of blood in an artery is controlled by the contraction and relaxation of the smooth muscle tissue. As the artery contracts, large amounts of blood are sent to an area. When the artery relaxes, the amount of blood flowing to the area is lessened. The outer wall of the artery contains flexible connective tissue. Connective tissue allows arteries to stretch and return to normal size with each heartbeat.

Your trip continues as you travel to smaller branching arteries. Where you go from here depends on many factors. For example, if a meal has recently been eaten, much of the blood will be directed toward the intestines to pick up food. If the body is exercising, the blood supply to the muscles will probably be increased. If there are a great many wastes in the blood, you may be sent to the liver, where certain wastes are changed into substances that are not poisonous to the body. Or you may travel to one of the kidneys, where other wastes are removed from the blood. No matter where you are sent, however, one thing is sure. You will find the

Activity Bank
The Squeeze Is On, p. 252

brain one of your primary destinations. For whether it is thinking very hard or not, the brain always gets priority over any other part of the body.

Capillaries: The Unseen Pipelines

The artery network carries blood all over the body. But arteries cannot drop off or pick up any materials from body cells. Can you think of a reason why not? *Hint:* Recall the description of the structure of an artery. The walls of arteries are too thick for oxygen and food to pass through. In order for the blood to do its main task—delivering and picking up materials—it must pass from the thick-walled arteries into very thin-walled blood vessels. Extremely thin-walled blood vessels are called **capillaries.**

You will probably have a hard time squeezing through the capillary in which you now find yourself. Don't feel bad. In most capillaries, there is only enough room for the red blood cells to pass through in single file. It is here in the capillaries that the basic work of the blood—giving up oxygen and taking on wastes—is carried out. Food and oxygen leak through the thin walls of the capillaries and enter the body cells. Wastes pass out of the body cells and enter the blood in the capillaries. Other materials transported by the blood can also leave and enter body cells at this time.

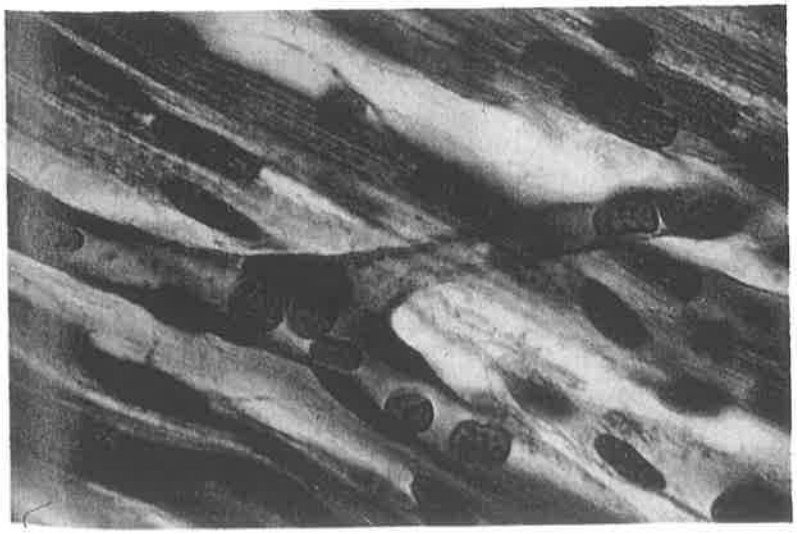
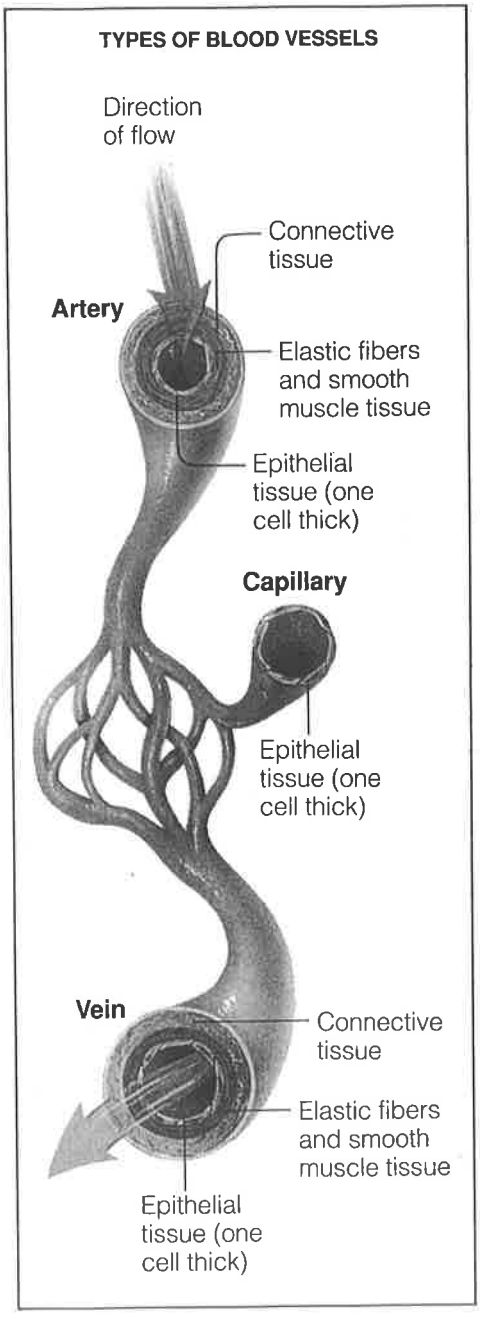


Figure 4–9 *Capillaries are so tiny that they permit only one red blood cell to squeeze through at a time. What is the function of a red blood cell?*

Figure 4–8 *The three types of blood vessels that make up the circulatory system are the arteries, capillaries, and veins. What is the function of each type of blood vessel?*



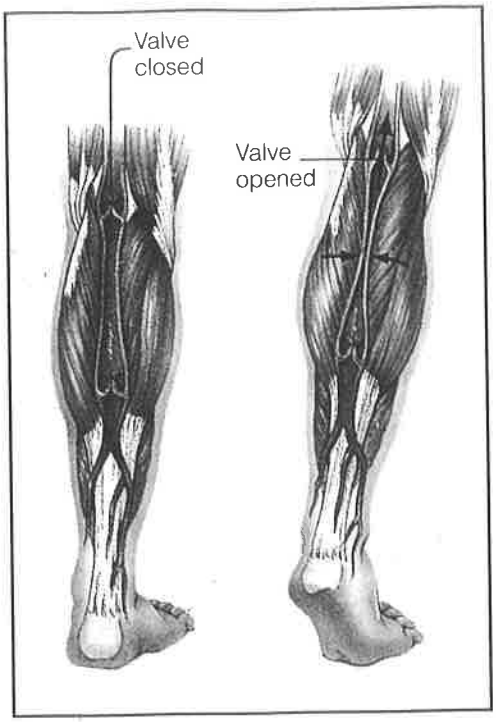


Figure 4–10 *Valves in the walls of veins prevent the backflow of blood and keep it moving in one direction—back to the heart. The contraction of nearby skeletal muscles such as those in the leg help the valves in performing this function.*

Veins: Pipelines to the Heart

Once the work of giving up oxygen and taking on wastes is completed in the capillaries, your trip through the circulatory maze is just about over. Because the blood has given up its oxygen, it is dark red again. The blood now starts back to the heart, trickling from the capillaries into blood vessels called **veins.** Veins carry blood back to the heart.

As you might expect, veins are much larger than capillaries. And unlike arteries, veins have thinner walls as well as tiny one-way valves. These valves help to keep the blood from flowing backward.

4–2 Section Review

1. Trace the path of blood through the circulatory system.
2. List the four chambers of the heart.
3. Describe the three types of blood vessels.
4. Explain why the walls of the ventricles are much thicker than the walls of the atria.

Critical Thinking—*Relating Facts*

5. Why is it important that veins contain valves?

Guide for Reading

Focus on this question as you read.

▶ *What are the four main components of blood?*

4–3 Blood—The River of Life

If you were to look at blood under a microscope, you would see that it is made up of tiny particles floating in a fluid. This makes blood a fluid tissue—one of the body's two fluid tissues. Lymph (LIHMF) is the other. Recall from Chapter 1 that a tissue is a group of cells that work together for a specific function.

The fluid portion of the blood is called **plasma.** And the tiny particles floating in the plasma are different types of blood cells and cell fragments—three different types, to be exact. **The three different types of floating particles—red blood cells, white blood cells, and platelets—and the plasma in which they float, are the four main components of blood.**